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ABSTRACT

This unit of instruction was designed as an introductory course in energy involving six simple machines, electricity, magnetism, and motion. The booklet lists the relevant state-adopted texts and states the performance objectives for the unit. It provides an outline of the course content and suggests experiments, demonstrations, field trips, and topics for student projects, reports, and discussions. Also listed are related mathematics problems, and relevant films available from the Dade County Audiovisual Center. Reference books are recommended, and a master sheet is provided relating each suggested activity to the specific performance objectives. (JR)

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AUTHORIZED COURSE OF INSTRUCTION FOR THE QUINMESTER PROGRAM

ENERGY: MACHINES

5311.03
5312.03
5313.03

SCIENCE
(Experimental)

DADE COUNTY PUBLIC SCHOOLS

DIVISION OF INSTRUCTION • 1971

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SCIENCE

(Experimental)

Written by June P. Castaldi
for the
DIVISION OF INSTRUCTION
Dade County Public School
Miami, Fla.
1971

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ENERGY: MACHINES

COURSE DESCRIPTION:

An introductory course in energy involving six simple machines, electricity, magnetism, and motion.

ENROLLMENT GUIDELINES:

None

STATE ADOPTED TEXTS:

1. Abraham, Norman et al. Interaction of Matter and Energy. Chicago: Rand McNally and Company, 1968.
2. Brandwein, Paul; Stollberg, Robert; Burnett, R. Will. Energy - Its Forms and Changes. New York: Harcourt, Brace and World, 1968.
3. Intermediate Science Curriculum Study. Probing the Natural World Vol. 1. Morristown, N. J.: Silver Burdett, 1970.
4. Marean, John and Ledbetter, Elaine. Investigating Matter and Energy. Menlo Park, California: Addison-Wesley, 1968.
5. Oxenhorn, Joseph and Idelson, Michael. Pathways in Science-Physics 1. New York: Globe Book Co., 1968.
6. Oxenhorn, Joseph and Idelson, Michael. Pathways in Science-Physics 2. New York: Globe Book Co., 1968.
7. Thurber, Walter, and Kilburn, Robert. Exploring Physical Science. Boston: Allyn and Bacon, Inc., 1966.

PERFORMANCE OBJECTIVES

The student will:

1. Given sufficient background information, create simple experiments to demonstrate at least three forms of energy.

2. Distinguish between potential and kinetic energy by citing examples of each.

3. Having experimented with the forces of gravity, friction, and inertia, relate two of these forces to personal experiences.

4. Given a number of simple machines, demonstrate their function.

5. Given a group of common tools used by man, propose reasons why one type of machine is better suited for a particular job than another.

6. Perform experiments that enable him to make accurate predictions based on an understanding of mathematical relationships to machines and electricity.

7. Given laboratory experiences, illustrate the magnetic fields.

8. Suggest reasons why a compass always points to the magnetic North.

9. Based on experiences with static electricity, demonstrate the theory of electric charges.

10. Given cells that produce electricity from chemicals, compare each as to structure and function.

11. Given series and parallel circuits, give examples where each would be applicable.

12. Given practical experience with selected electrical devices, discover how they work.

COURSE OUTLINE

I. Energy

A. Energy and work

B. Potential and kinetic energy

C. Transformation of energy

D. Forms of energy

II. Forces and Motion

A. Friction

B. Gravity

C. Inertia

D. Measuring force

E. Force and work

F. Newton's laws of motion

III. Machines

A. Machines and work

B. The law of machines

C. Efficiency of machines

D. Mechanical advantage

E. Power

F. The six simple machines

1. Structure and function
2. Applications

IV. Magnetism and Electricity

A. Magnetism

1. Behavior and law of magnets
2. Magnetic fields
3. Kinds of magnets
4. Uses of magnets
5. The magnetic compass

B. Electricity

1. The electrical nature of matter
   a) Theory of electrical charges
   b) Conductors and insulators
2. Static electricity
3. Electricity from chemicals
   a) The Voltaic cell
   b) The dry cell
   c) The storage cell (battery)
4. Current electricity
   a) Electrical units of measurement
   b) Electric current in series and parallel circuits

C. Using electricity and magnetism

1. Electricity creates magnetism
   a) Machines developed using this principle
   b) Structure and operation of selected machines
2. Electricity from magnetism
   a) The electric generator
   b) The transformer
   c) Applications

EXPERIMENTS

Davis, Ira, et al. Science 1: Observation and Experiment. New York: Holt, Rinehart, and Winston, 1965.

1. Dry cell structure. (p. 220)
2. Making a magnet (p. 248)
3. Effects of magnets (p. 250)
4. Magnetic properties (p. 251)
5. Magnetic fields (p. 252)
6. Lines of force around magnets (p. 253)
7. Transferring magnetic properties by induction (p. 254)
8. How do you make a compass? (p. 255)
9. Materials attracted to magnets (p. 258)
10. Make an electromagnet (p. 262)
11. How do you make a permanent magnet? (p. 263)
12. How does an electric doorbell work? (p. 265)
13. How does a telegraph work? (p. 266)
14. How can magnets be used to generate electricity? (p. 270)

Strumeyer, Joseph and Harris, Dennis. Exercises and Investigations for Science 1. New York: Holt, Rinehart, and Winston, 1965.

15. Electricity in action (Inv. 7A p. 63)
16. Electrical applications (Inv. 7B p. 65)
17. Electricity and magnetism (Inv. 8A p. 69)
18. The electromagnet (Inv. 8B p. 71)

Davis, Ira, et al. Science 2: Experiment and Discovery. New York: Holt, Rinehart, and Winston, 1965.

19. Friction (p. 44)
20. What is friction? (p. 45)
21. Friction and gravity (p. 46)
22. How do potential energy and kinetic energy differ? (p. 51)
23. How can one form of energy be changed into another? (p. 54)
24. How can running water be used as a source of energy? (p. 56)
25. Force and work (p. 59)
26. How does a lever help you do work? (p. 87)
27. How does a wheel and axle help you do work? (p. 84)
28. How do pulleys help you do work? (p. 87)
29. How does an inclined plane help you do work? (p. 87)
30. How do you use a doorknob as a machine? (p. 92)
31. What tools do you use around the house? (p. 94)

Strumeyer, Joseph and Harris, Dennis. Exercises and Investigations for Science 2. New York: Holt, Rinehart, and Winston, 1965.

32. The Lever, movements, and work (Inv. 3A p. 33)
33. Effort force and distance of movement (Inv. 3B p. 37)

Davis, Ira, et al. Science Discovery and Progress. New York: Holt, Rinehart, and Winston, 1965.

34. Forces (p. 130)
35. Forces (p. 135)
36. Mechanical Advantage (p. 141)
37. Inclined plane (p. 144)
38. Compasses and the North pole (p. 174)
39. Magnetic fields (p. 175)
40. Making an electromagnet (p. 189)
41. The electric bell (p. 190)
42. Electroplating (p. 162)
43. Circuits (p. 191)
44. Galvanometer (p. 196)

Strumeyer, Joseph and Harris, Dennis. Exercises and Investigations for Science Discovery and Progress. New York: Holt, Rinehart, and Winston, 1965.

45. Relationship between effort force and distance of movement (Inv. 6A p. 45)
46. Relationship between effort force and work done (Inv. 6B p. 49)
47. Static and current electricity (Inv. 7A p.55)
48. Producing electricity (Inv. 7B p. 57)
49. An electric current through a wire produces a magnetic field (Inv. 8A p. 69)
50. The electromagnet (Inv. 8B p. 69)
51. Newton's Laws of Motion (Inv. 14A p. 121)
52. Discovering facts about rockets (Inv. 14B p. 123)

Oxenhorn, J. and Idelson, M. Pathways in Science:-Physics 1. New York: Globe Book Co., 1968.

53. Electric current (p. 11)
54. Voltage (p. 21)
55. Current in circuits (p. 24)
56. Voltage in circuits (p. 25)
57. Current and resistance (p. 30)
58. Conductor and size (p. 31)
59. Resistance in a conductor (p. 36)
60. Magnets (p. 62)
61. Making a magnet (p. 68)
62. Transferring magnetism (p. 72)
63. Electricity creates magnetism (p. 91)
64. Making an electromagnet (p. 92)
65. Model telegraph (p. 98)
66. Magnetism produces an electric current (p. 99)
67. Making an electric generator (p. 104)
68. Inducing high voltage (p. 112)

Oxenhorn, J. and Idelson, M. Pathways in Science:-Physics 2. New York: Globe Book Co., 1968.

69. How is motion related to energy? (p. 22)
70. How does a chemical change release potential energy? (p. 32)
71. How can gravity change potential energy to kinetic energy? (p. 39)
72. How are forces measured? (p. 43)
73. How can we show inertia? (p. 47)
74. How can you show work? (p. 76)
75. Wheel and axle (p. 92)
76. Inclined plane (p. 102)
77. Screw (p. 106)
78. How does friction waste work? (p. 111)
79. How do chemicals reduce friction? (p. 112)

Thurber, W. and Kilburn, R. Exploring Physical Science. Boston: Allyn and Bacon, Inc., 1966.

80. Friction (pp. 146-151)
81. Work (pp. 152-153)
82. Inclined planes (p. 154)
83. Wedges (p. 155)
84. Mechanical advantage (pp. 156-157)
85. Pulleys (pp. 158-159)
86. Wheel and axle (pp. 160-161)
87. Mechanical advantage of levers (p. 163)
88. Levers (pp. 164-165)
89. Potential and kinetic energy (pp. 167-168)
90. Energy changes (p. 169)
91. Power (p. 171)
92. Forces (#2 p. 172)
93. Mechanical advantage (#3 p. 172)

94. Perpetual motion (#4 p. 172)
95. Pendulum (#5 p. 172)
96. Horsepower (#6 p. 173)
97. Energy (#7 p. 173)
98. Friction (#8, #9 p. 173)
99. Force (#10 p. 173)
100. Efficiency (#11 p. 173)
101. Horsepower (#12 p. 173)
102. Parallel and Series Circuits (p. 244)
103. Converting electrical energy (pp. 252-253)
104. Electrical conduction (#1,2,3,4, p. 268)
105. Circuits (#7,8 p. 269)
106. Heat and electricity (#10 p. 269)
107. Static electricity (pp. 306-309)
108. Nature of charged objects (pp. 312-313)
109. Charged objects discharging (pp. 314-317)
110. Conductivity of liquids (p. 319)
111. Electrochemistry (p. 320)
112. Galvanometer (p. 324)
113. Testing electric cells (p. 325)
114. Storage cell (p. 327)
115. Electrochemistry (#1 p. 332) (#3 p. 332)
116. Dry Cell (#3 p. 332)
117. Static electricity (#5 p. 332)
118. Electric charges (#6 p. 332)
119. Volta's cell (#9 p. 332)
120. Properties of electrons (p. 338)
121. Magnetically induced currents (p. 340)
122. Magnetic effect of moving electrons (pp. 344-345)
123. Electromagnets (p. 346)
124. Magnetic fields in a coil (pp. 346-347)
125. Simple generator (p. 371)
126. Exploring a circuit (pp. 377-378)
127. Electrical resistance (p. 380)
128. Transformers (pp. 385-386)
129. Electric motors (pp. 391-392)

Suggestion: Have your school invest in a class set of Exploring Physical Science Record Book by Thurber, Kilburn and Seager, published by Allyn and Bacon, 1970. This is a laboratory manual containing all the experiments and suggestions from the text neatly laid out in lab form. It will save you a great amount of time and trouble.

DEMONSTRATIONS

Most of these can be done as laboratory experiments if equipment is available.

Davis, Ira, et al. Science 1: Observation and Experiment. New York: Holt, Rinehart, and Winston, 1965.

1. How can we produce electricity by chemical action? (p. 217)
2. How does a generator produce electric current? (p. 220)
3. How does electric current pass through an electric light bulb? (p. 224)
4. How can we heat a wire with electricity? (p. 227)
5. How can we make a fuse? (p. 231)
6. What is the voltage of dry cells in series? (p. 232)
7. How are Christmas tree lights connected in series? (p. 233)
8. How are appliances connected in parallel? (p. 235)
9. Will magnets attract non-magnetic materials? (p. 258)
10. How does a wire carrying electricity act on iron? (p. 260)
11. Does a wire carrying electricity attract a compass needle? (p. 260)
12. How does a coil of wire carrying electricity affect a compass? (p. 262)
13. Is a U-shaped electromagnet stronger than a straight one? (p. 264)
14. How does an electric motor use electromagnets? (p. 268)

Davis, Ira, et al. Science Discovery and Progress. New York: Holt, Rinehart, and Winston, 1965.

15. What causes the mechanical advantage of an inclined plane? (p. 142)
16. What is the relationship between a screw and an inclined plane? (p. 145)
17. How can you produce static electricity? (p. 156)
18. How do electrons behave? (p. 158)
19. How do you make an electric cell? (p. 159)
20. Is a dry cell dry? (p. 161)
21. What is a lead storage battery? (p. 163)
22. How does a series circuit work? (p. 166)
23. What is the effect of cells in series? (p. 167)
24. What relationship exists among resistance, volts, amperes? (p. 168)
25. How is voltage affected by parallel circuits? (p. 170)
26. What is the effect of adding resistance to parallel circuits? (p. 171)
27. What are the effects of a magnet? (p. 173)
28. What did Oersted discover? (p. 187)
29. What is the shape of a magnetic field around a wire? (p. 187)
30. How does a motor operate? (p. 193)
31. Can a magnetic field produce current? (p. 196)
32. How does a magnet generate electricity? (p. 196)
33. What is induction? (p. 199)
34. How is a telegraph message sent? (p. 200)
35. How does a telephone transmit sound? (p. 202)
36. How does a rocket move? (p. 359)

PROJECTS

1. Use a watch to measure the approximate time needed for a heavy object to fall 4, 16, 64, etc. feet.
2. Check Galileo's experiment by dropping two objects of equal size but different weights from a height of 20 feet or more.
3. Stand on a bathroom scale in an elevator. Note the readings as the elevator accelerates, decelerates and travels at a steady rate of speed.
4. Make an accelerometer and find out when a vehicle is accelerating/decelerating.
5. Prepare an exhibit of common pounding tools used in the home, or small shops.
6. Build a model pile driver.
7. Make a display of simple machines.
8. Make a display of compound machines.
9. Make a collection of different kinds of incandescent lamps.
10. Find out how many things in your home use electromagnets.
11. Make a collection of insulators and conductors and mount them on a display board.
12. Send to a company making electric bulbs for a chart or exhibit of the steps in making a bulb. Study the bulb and show how they are put together.
13. Make a plan of the electric wall outlets in your home, classroom, or school building. Are they in the right places for the purposes for which they are used? Suggest improvements.
14. Participate in a "tug-of-war" with your classmates. Try to balance the teams. Observe what happens when forces are in balance, out of balance, etc., and give reasons for your observations.
15. Devise and conduct an experiment in which you use a dry cell and a small lamp to compare the conductivity of copper wire and iron wire. What must be controlled? What evidence could you use to show which wire is the better conductor?
16. Obtain an old discarded car battery. Examine its parts and construction. How many cells are in the battery? Are the cells connected in series or in parallel? How can you tell?

REPORTS

1. Isaac Newton and His Great Contributions
2. Archimedes
3. Thomas A. Edison
4. Perpetual Motion Machines
5. Early Weapons and Tools
6. Starting and Stopping Distances of Autos Traveling at Different Speeds Under Different Conditions
7. How Jet Planes and Propeller-driven Planes Decelerate in the Air and on the Ground

FIELD TRIPS

1. A forging plant and report on methods used to pound hot metal into various shapes.
2. A shop class in school and have the teacher explain the different machines.
3. A local power company.
4. A local service station. Have a battery charger explained and demonstrated.
5. A junkyard to see a crane in action.
6. Cape Kennedy.
7. The telephone company.
8. An auto racetrack. Find out why curves are banked, etc.
9. A trackmeet. Calculate the speed of the runners.

RELATED MATH PROBLEMS

1. Determine the mechanical advantage of a bicycle by comparing the force exerted on the pedal with the force produced at the rim of the rear wheel.

2. Calculate your horsepower while riding a bicycle. While sitting, push down on a set of scales with one foot to obtain an estimate of the force exerted on the bicycle pedal. Measure also the distance the pedal is pushed during each revolution and the number of revolutions per minute that it turns. Calculate your power in foot-pounds per minute, and your horsepower.

3. How much does an object weigh if 96 foot-pounds of work are required to lift it a foot?

4. How much work does a 110 pound boy accomplish when he climbs a stairway 50 feet hight?

5. How long is an inclined plane if you can use it to raise a 75 pound load of bricks 3 feet above the ground while exerting 15 pounds of force?

6. Measure the force required to turn a person around on a piano stool. Measure the distance through which this force is exerted. Calculate the input and the output (the weight of the person x height lifted). Find the efficiency of the screw.

7. How many watts are used by a toaster in which 4 amperes of current are flowing under a pressure of 120 volts? (Watts=volts x amperes.)

8. If a 600-watt iron is connected to a 120-volt line, how many amperes of current will flow through the iron?

9. What is the pressure in volts when 3 amperes of current are flowing through a 345 watt appliance?

10. How many foot-pounds of work are done when 25 pounds is lifted to a height of 4 feet. (Work=Force x Distance)

11. How far is a weight of 6 pounds lifted if 240 foot-pounds of work are done?

12. How much weight must be lifted a distance of 20 feet if 100 foot-pounds of work are done?

13. How many foot-pounds of work are done when a weight of 80 pounds is lifted a distance of 9 feet?

14. What weight must be lifted a distance of 320 feet if 2240 foot-pounds of work are done?

FILMS AVAILABLE FROM DADE COUNTY AUDIOVISUAL SERVICES

The following films have been categorized according to major topics.

A. ENERGY

1. Energy
   AV#1-01718, 11 minutes, BW
2. Energy and Its Transformations
   AV#1-01722, 11 minutes, BW
3. Energy and Work
   AV#1-01719, 11 minutes, C
4. Energy from the Sun
   AV#1-01598, 11 minutes, BW
5. Energy in our Rivers
   AV#1-03538, 10 minutes, BW
6. Nature of Energy
   AV#1-01733, 10 minutes, BW

B. FORCES AND MOTION

7. Action-Reaction
   AV#1-01781, 10 minutes, BW
8. Centrifugal Force
   AV#1-10698, 13 minutes, BW
9. Force
   AV#1-01785, 10 minutes, BW
10. Force and Motion
    AV#1-01748, 10 minutes, BW
11. Force of Gravity
    AV#1-30285, 29 minutes, C
12. Forces
    AV#1-10697, 14 minutes, C
13. Gravity
    AV#1-01787, 10 minutes, BW
14. Gravity and Center of Gravity
    AV#1-01730, 12 minutes, BW
15. Gravity: How It Affects Us
    AV#1-10704, 14 minutes, BW
16. Gravity: The Mighty Pull
    AV#1-10705, 13½ minutes, C
17. Inertia of Motion
    AV#1-01780, 10 minutes, BW
18. Laws of Motion
    AV#1-10682, 12 minutes, BW

C. MACHINES

19. The Lever
    AV#1-10708, 10 minutes, BW
20. Work and Power
    AV#1-10684, 14 minutes, C
21. ABC of Hand Tools (Part I)
    AV#1-11397, 18 minutes, C

22. ABC of Hand Tools (Part II)
AV#1-12945, 18 minutes, C
23. Machines Do Work
AV#1-01758, 11 minutes, BW
24. Machines That Move Earth
AV#1-11394, 18 minutes, C
25. The Pulley
AV#1-30727, 12 minutes C
26. Wheel and Axle
AV#1-01796, 10 minutes, BW

D. MAGNETISM
27. Magnetic Force
AV#1-30321, 29 minutes, C
28. Magnetism
AV#1-01899, 10 minutes, BW

E. ELECTRICITY
29. Static Electricity
AV#1-01904, 10 minutes, BW
30. Electrons
AV#1-03541, 11 minutes, BW
31. Electrons at Work
AV#1-10762, 14 minutes, C
32. Electrostatic Charges and Forces
AV#1-10754, 14 minutes, BW
33. Principles of Electricity
AV#1-13111, 20 minutes, C
34. Electric Circuits
AV#1-01890, 10 minutes, BW
35. Electricity All About Us
AV#1-01886, 11 minutes, C
36. Electricity: How To Make A Circuit
AV#1-03547, 11 minutes, C
37. Electricity: Principles of Safety
AV#1-01910, 11 minutes, C
38. Electrochemical Reaction
AV#1-10929, 14 minutes, BW
39. Electrochemistry
AV#1-01961, 11 minutes, BW
40. Ohm's Law
AV#1-01902, 5 minutes, BW

F. ELECTRICITY AND MAGNETISM
41. Electric Lines of Force
AV#1-01907, 7 minutes, BW
42. Electromagnetic Induction
AV#1-10776, 14 minutes, BW
43. Principles of Generators
AV#1-01912, 10 minutes, BW

SUGGESTED DISCUSSION QUESTIONS

1. Why did scientists of the 16th, 17th, and 18th centuries learn so much more about electricity than the people of ancient Greece?

2. Why do you sometimes see a chain dangling from the rear of a gasoline truck?

3. What is the purpose of the wire that sticks up from the roadway at the approach to a toll station?

4. Why do we think the Earth is a magnet?

5. "Give me a long enough lever and a place to rest it and I can lift the world," Archimedes said. What did he mean?

6. Why isn't a bird injured when he rests on a power line?

7. When you turn on a light, the bulb lights, but it also gets hot. When you use an electric toaster, the toaster gets hot, but it doesn't light up like a bulb. How do you explain this?

REFERENCES

1. Abraham, Norman et al. Interaction of Matter and Energy. Chicago: Rand McNally and Company, 1968.

2. Brandwein, Paul et al. Energy. New York: Harcourt, Brace and World, 1968.

3. Brandwein, Paul et al. Exploring the Sciences. New York: Harcourt, Brace and World, 1964.

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5. Davis, Ira et al. Science 2-Experiment and Discovery. New York: Holt, Rinehart, and Winston, 1965.

6. Davis, Ira et al. Science Discovery and Progress. New York: Holt, Rinehart, and Winston, 1965.

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10. Oxenhorn, J. and Idelson, M. Pathways in Science-Physics 2. New York: Globe Book Co., 1968.

11. Strumeyer, J. and Harris, D. Exercises and Investigations for Science 1. New York: Holt, Rinehart, Winston, 1965.

12. Strumeyer, J. and Harris, D. Exercises and Investigations for Science Discovery and Progress. New York: Holt, Rinehart, and Winston, 1965.

13. Tracy, George et al. Modern Physical Science. New York: Holt, Rinehart and Winston, 1970.

MASTER SHEET - ENERGY: WORKINGS

Objectives	Experiments	Demonstrations	Projects	Reports	Field Trips	Math Problems	Libr.	Discussion Questions
1	22,23,24,69,90, 97,101 97,101		14		1,3,7,6		1,2,3,4,5,6	
2	22,23,24,69,70, 71,89,90,97	36			1,3,7,6		1,2,3,4,5,6	
3	19,20,21,25,31, 35,51,52,72,73, 74,78,79,80,92, 94,95,98,99	36	1,2,3,4	1,2,6,7	6,8,9	6	7,8,9,10,11, 12,13,14,15, 16,17,18	
4	26,27,28,29,30, 32,75,76,77,82, 83,85,86,88	16	7, 8	3, 5	2, 5		19,20,21,22, 23,24,25,26	5
5	30,31,33,36,45, 46,84,87,91	15, 16	6, 8	4	2, 5		19 through 26	
6	15,42,43,48,53, 54,55,56,57,58, 59,68,104,112, 116,118,120, 126,127	18,22,23,24,25, 26	15	3		1 through 14	32 through 37 & 40	1, 6
7	2,3,4,5,6,7,9, 10,11,14,17,18, 39,40,49,60,61, 62,63,64,66, 121,122,123,124	9,10,11,12,13, 27,28,29,30,31, 32,33	10		5,3,7		27,28,42,41	4
8	8,38,60						27,28	8
9	47,107,108,109, 117,118,120	17, 18					29,30,32	2, 3
10	1,42,103,110, 111,113,114, 115,116,119	1,19,20,21	16		4		38, 39	
11	43,44,48,53,54,55 55,56,57,58,59, 68,102,104,105, 112,118,126, 127	3,4,7,8,10,22, 23,24,25,26	9,11, 12,13, 15		3, 7	7,8,9	30,31,32,33, 34,35,36,37, 40	1, 2
12	12,13,14,16,41, 50,65,67,123, 125,128,129	14,30,34,35			2,3,7	7,8,9	43	